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A STUDY OF THE EFFECTS OF LONG-TERM GROUND AND FLIGHT ENVIRONMENT EXPOSURE ON THE BEHAVIOR OF GRAPHITE-EPOXY SPOILERS

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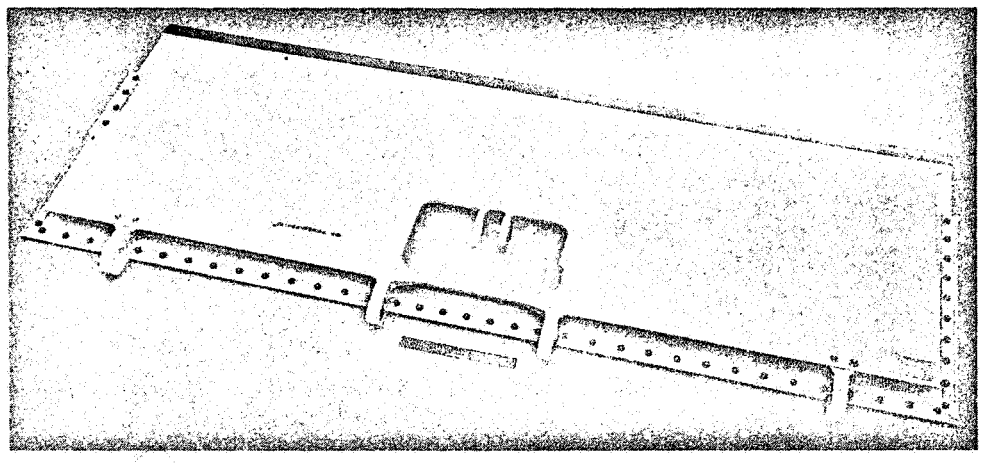
By Robert L. Stoecklin



Seventh Quarterly Progress Report

April 1974

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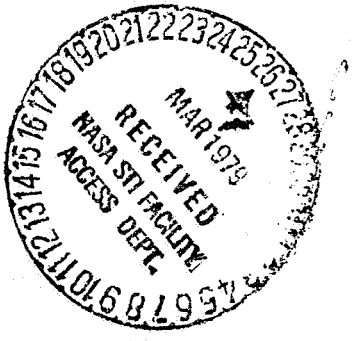

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16. Abstract

This quarterly report is prepared in compliance with the requirements of contract NAS1-11668 and covers the work performed from January 1, 1974 through March 31, 1974. Task I of this contract is in progress and consists of procurement and production activities required to implement the production run of 114 Boeing-designed graphite flight spoilers for the 737 airplane. The task II effort, which includes design and fabrication of an advanced-design, all-composite spoiler, is also in progress. Task I flight spoilers are being flown on commercial 737s in a 5-year program to gather data on the environmental durability of graphite-epoxy material systems. Task II spoilers will join this flight program in 1974.

Task III, a ground-based environmental exposure program, and task IV, a production program for 25 additional task I spoiler units, are additional portions of this contract and are in progress.

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A STUDY OF THE EFFECTS OF LONG-TERM GROUND AND FLIGHT ENVIRONMENT EXPOSURE ON THE BEHAVIOR OF GRAPHITE-EPOXY SPOILERS

By Robert L. Stoecklin
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SUMMARY AND PROGRAM STATUS

This seventh quarterly progress report is submitted in accordance with the requirements of contract NAS1-11668 and covers the work performed during the period from January 1 through March 31, 1974.

The objective of this program is to produce 114 task I and 11 task II 737 flight spoilers for laboratory testing and service-evaluation deployment. Four task I spoilers are being installed on each of 27 aircraft representing 5 major airlines operating in different environmental circumstances. These units are being monitored under actual load and environmental conditions for a period of 5 years. Selected units will be removed periodically to evaluate any material degradation as a function of time. Task II spoilers will be phased into the evaluation program as additional installations as well as replacements for task I spoilers removed for evaluation and testing. Task III consists of fabricating and positioning six environmental exposure racks in various parts of the world to gather ground-based environmental data to support the flight data gathered from the spoilers. Task IV consists of fabricating 25 additional spoiler units of task I design for NASA laboratory study.

Activities for the seventh quarter have produced the following significant events:

- Completion of the remaining quality control evaluations on task I spoilers
- Continued development work on the task II integral hinge/spar fitting and the graphite/polysulfone skins
- Identification of the fifth participating airline in the service-evaluation program

- Impending sale of several participating 737 aircraft to a sixth airline
- Continuation of the task IV fabrication effort

The remaining 32 task I spoiler units were shipped to the fifth participating airline during this period. At the close of the quarter, 92 units have been installed and are in service. In addition, one spare spoiler unit was shipped to NASA-Langley for administration support activity.

DESIGN

QUALITY CONTROL

Activity for this reporting period has focused primarily on the following items:

- Completion of the outstanding NDT discrepancies related to the task I production effort
- Exploratory NDT investigations of the prototype task II integral hinge/spar fitting
- Evaluation of the repair activity performed on spoiler S/N 0105

At the close of the preceding quarter, there were two task I units requiring further quality control evaluations. In addition, an assessment of the graphite/epoxy skin repair on S/N 0105 was required to return the damaged spoiler to flightworthy status.

The original scans on spoilers S/N 0100 and 0103 lacked sufficient definition. With the return of the NDT equipment to operational status, these two spoilers were rerouted through the NDT processing. Table 1 has now been completed.

The rescan of S/N 0100 showed no discrepancies with the original NDT scan and was thus accepted. Consequently, Quality Control cleared the planning paperwork. The rescan of S/N 0103 duplicated the 54-60 dB attenuation on the right hinge arm of the center hinge fitting that was noted on the original NDT scan. Reexamination of the physical features of the hinge fitting disclosed that the attenuations were occurring over the 0.95-in.-diameter machining access hole in the hinge fitting. While the open hole should, theoretically, show complete attenuation, apparently a portion of the signal was seeking a "detour" path around the periphery of the hole and yielding local indications greater than 0 dB. No indications of attenuations were noted adjacent to the access hole, thus clearing this spoiler for acceptance.

Following the skin repair of spoiler S/N 0105 (reported in the sixth quarterly report), the spoiler was rescanned and found to be free of defects. The spoiler was released back to final assembly for refinishing and return to flightworthy status.

The second task II all-composite fitting (drawing LP-314591, sixth quarterly report) was inspected prior to its incorporation into the prototype frame. Ultrasonic through-transmission was used on the hinge arm-to-spar bond and low-voltage X-ray was used around the center hinge fitting, including the hinge arms. Through-transmission revealed some discrepant areas tentatively diagnosed as porosity in the EA9628 bondline. This area will be further assessed following static test of the prototype. The low-voltage X-ray disclosed small, discrepant areas that appeared to be resin voids where graphite plies either turn corners or butt against companion plies. Small evidence of porosity was also revealed around the hinge joints. The assembly was approved for prototype use.

Because of the high cure temperatures and pressures required for the graphite/polysulfone skins, it will be necessary that curing be performed in the Materials Laboratory autoclave. Arrangements have been made to provide for in-process inspection in the Engineering Laboratory and visual and dimensional inspection of the completed skins.

ENGINEERING DESIGN

Resolution of the NDT assessments on the remaining two task I spoilers (plus the NDT examination of the skin repair to S/N 0105) has marked the completion of task I fabrication activities. No further fabrication reporting will be required except for potential repair activities.

No additional task III exposure rack deployment activity has occurred, but airline negotiation activity is generating a potential site for deployment of the fifth rack.

The principal engineering activities for this quarter were associated with the commencement of task IV fabrication activities and the further development work on the task II prototype (designated 65-76327-XY). A total of 12 task IV frame assemblies have been completed, of which 3 have been laid up into first-stage bond assemblies. No second-stage bond assemblies have been completed due to the low properties recorded by receiving inspection on both the 5- and 10-mil EA9628 adhesive. Both lots were returned to the vendor on February 14. A replacement shipment of EA9628 has been scheduled. The replacement shipment was pending at the close of the quarter.

The integral hinge/spar fitting assembly for the 65-76327-XY prototype was completed by NASA-Langley and shipped to Boeing on March 19. Prior to delivery to Auburn, the unit was assessed by Quality Control, using both ultrasonic and low-voltage X-ray techniques. The unit was

delivered to Auburn on March 28. Fabrication of the prototype unit, followed closely by the prototype static test, will be accomplished in the coming quarter.

The Structural Materials group has been working closely with the polysulfone vendor toward fabrication of the prototype skin units. The graphite/polysulfone tape for this program is XR 3023 Thornel 300/P-1700, purchased from U.S. Polymeric. The 10-lb order of this material delivered in December 1973 was evaluated by the Structural Materials group and found to be unsatisfactory in fiber distribution and fiber collimation. The shipment was returned to the vendor. In March, a 3-ft sample of prepreg tape submitted for evaluation was assessed as satisfactory. A 10-lb replacement shipment has been scheduled by U.S. Polymeric for delivery to Boeing in April.

The polysulfone matrix is stable at room temperature, and no special storage requirements exist except to keep it from being exposed to contaminants. Laminate layup is accomplished using a hot-pressing hand iron to eliminate tape curl and tacking the butt line of the tape with a heavy-duty solder iron. Basic tool construction is magnetic steel. Bagging material is 2-mil Kapton polyimide film edge sealed or envelope bag sealed with SWS 7220 silicone rubber. Compaction and densification of the laminate plies are accomplished by autoclaving or pressing at 600° F and 200 psi for 1 hr (fig. 1).

Steel tools for both the flat upper skin and the curved lower skin have been ordered. New skin tools were necessary due to the higher pressures and temperatures needed to cure the graphite polysulfone composite (600° F and 200 psi). The smaller Materials Laboratory autoclave, which will be utilized for task II skin fabrication, will accommodate only one skin unit at a time, as opposed to the task I epoxy skins that were laid up and cured four at a time in the large Auburn autoclaves. In addition, the contoured skin tool used in task I is fabricated from fiberglass, which is not compatible with the 600° F curing temperature.

Preparation of the processing document (D6-32541-2) covering the polysulfone skins has been completed and is in the review process prior to release.

Investigation into the resistance of the polysulfone resin to stress cracking in the presence of contaminating fluids has been conducted. The stress testing of graphite/polysulfone (Gr/Ps) composite is performed with the Bergen stress crack resistance test jig (fig. 2). A rectangular strip of the material is bent over the jig, which has a varying radius surface. This curvature imparts a tensile strain on the outer surface of the material. The jig surface is defined by a quadrant of the ellipse $(y/1.5)^2 + (x/5)^2 = 1$. Under these test conditions stress cracking is a function of strain rather than stress. Test specimen strain is determined from stress imposed on the specimen by the radius of curvature of the test jig. The relationship of strain to distance along the elliptical surface of the Bergen test jig is presented in figure 3. By measuring the distance from the gage line to the nearest

crack, the lowest strain at which crazing or cracking occurs can be determined. Although this method was originally developed for testing unreinforced plastic sheet, the influence of reinforcing fiber does not appear to interfere with predicted matrix crack initiation.

Specimens in the Bergen test jig have been exposed to several fluid contaminants, including Skydrol 500 and GMC cleaning solution. The results of these tests are graphically presented in figure 4. Due to the location and operational envelope of the flight spoiler, the risk associated with exposure of Gr/Ps material to these contaminants while under load is extremely remote.

PROCUREMENT

GRAPHITE MATERIALS

The 10-lb order of P-1700 graphite/polysulfone prepreg tape delivered in December 1973 was evaluated by the Structural Materials group and found to be deficient in volume fraction (and consequently mechanical properties). The shipment was placed on rejection status and returned to the vendor. A 10-lb replacement shipment has been scheduled by U.S. Polymeric for delivery to Boeing in April.

FITTINGS AND DETAILS

The only fitting procurement activity was the NASA shipment of the prototype integral hinge/spar fitting. Upon completion of a successful static test on the prototype task II spoiler, NASA has indicated its ability to support the task II production schedule.

PRODUCTION

Production activities for the current quarter have been confined to task IV, with tasks I and III having been completed and no activity scheduled for task II. A total of 12 frame assemblies were completed, and 3 of these units were used to complete first-stage assemblies with contour machined honeycomb core. No second-stage assemblies have been laid up, due to the lack of qualified EA9628 adhesive. Resolution of the adhesive qualification problem is anticipated shortly.

AIRPLANE COORDINATION

On February 8, negotiations were concluded with Piedmont Airlines to participate in the service-evaluation program as the fifth participating airline. Conclusion of this agreement permitted shipment of the 32 remaining task I spoilers to Piedmont during the month of February. Spoiler installations began in Winston-Salem, N.C., on February 28 and at the close of the quarter, 4 of these shipsets (16 spoilers) had been installed and placed in service. These installations, plus the 76 spoilers previously reported to be in service, give a new total of 92 spoilers now installed and in service. The remaining 16 spoilers are expected to be in service by early May.

PSA Airlines has notified Boeing of its plans to sell four 737 aircraft to Viacao Aerea Sao Paulo Airlines (VASP) of Brazil. These four aircraft are all currently participating in the spoiler program. As a result of this plan, and in concurrence with NASA-Langley, VASP will be approached with an invitation to participate in the flight-service evaluation with the aircraft acquired from PSA. VASP participation would present an attractive opportunity to deploy the fifth environmental exposure rack in South America, which had not been previously contemplated. Favorable response from VASP is anticipated.

As a consequence of the pending sale of aircraft by PSA, the role of PSA in the service-evaluation program would necessarily be revised. It is anticipated that PSA would continue to operate the one remaining aircraft equipped with task I spoilers, and that an additional aircraft will be fitted with two task II spoilers and the two "spare" task I spoilers that are no longer needed as standby units to support the initial task I deployment schedule.

At the conclusion of the quarter, a total of 84 830 flight hours and 140 680 landings had been accumulated on the 92 units installed and in service. Tables 2 and 3 compile the task I graphite spoiler service experience as of March 31.

GENERAL

PROGRAM SCHEDULE AND PROGRESS

Program progress during this period has been slowed, principally due to difficulties in the materials supply area. However, those problems have been actively pursued and are either under control or will soon be under control. The task IV production period will be extended to compensate for the delays in schedule. All task IV units are scheduled for laboratory test and do not affect the service-evaluation program.

The polysulfone procurement delay has caused a schedule delay in the task II program. Completion of fabrication and testing of the prototype unit will not occur until sometime in the coming quarter. The program schedule, given in figure 5, reflects these changes.

The addition of Piedmont Airlines as the fifth participating airline in the service-evaluation program completes the schedule of participants. Piedmont is expected to become a significant contributor to the success of the program.

Should the sale of participating 737s to a sixth airline materialize, we will attempt to place the remaining exposure rack with the sixth airline. Otherwise, a neutral, arbitrary site will be selected as an additional source of exposure data.

TASK I

Quality Control evaluation of the remaining units (S/N 0100 and 0103) has completed the production effort for task I. The repaired spoiler S/N 0105 successfully passed NDT inspection and was returned to stores as a flightworthy spare.

The remaining 32 task I spoiler units were shipped to Piedmont Airlines in February. By the close of the quarter, 16 of these had been placed in service.

TASK II

Development of the second molded hinge fitting for the task II prototype has been successfully completed. The second unit has incorporated the design modifications adopted following the premature failure of the first test unit reported in the sixth quarterly report. The drawings in the appendix of that report accurately reflect the features of this unit. Figure 6 shows a closeup of the composite center-hinge fitting for the prototype unit.

The unit arrived at Boeing on March 22. Following the ultrasonic and X-ray examinations, the unit was delivered to Auburn where it was successfully fit-checked into the assembly jig tool. The unit was then placed into stores, pending planning for prototype assembly.

Development of the polysulfone skins for the task II prototype has been impeded by low-volume-fraction prepreg tape. Coordination with the prepreg supplier has identified the difficulty. Since there is no bleedout with the polysulfone resin, the fiber fraction is completely defined in the prepreg tape. Mechanical property data confirmed the low fiber volume.

New skin tools for fabrication of single skins, both upper and lower, have been ordered and are scheduled for delivery in April. Fabrication of the skins is expected to pace the prototype fabrication.

TASK III

Deployment of the fifth airline exposure rack is still pending. Piedmont Airlines is not participating in this portion of the program due to their geographic proximity to Hampton, Virginia, where NASA is gathering ground-exposure data of a similar nature. Selection of an arbitrary site for the fifth exposure rack is being withheld until deployment with the potential sixth airline has been thoroughly examined.

TASK IV

Assembly of the task IV spoilers has proceeded at a modest rate during the quarter. Completion of second-stage bond units has been hampered by the lack of qualified 5- and 10-mil EA9628 adhesive. The vendor has agreed to replace the shipments already delivered. As a result, only 12 frame assemblies and 3 first-stage bond assemblies were completed during this period. Significant production activity is anticipated in the coming quarter.

Boeing Commercial Airplane Company
P.O. Box 3707
Seattle, Washington 98124, June 11, 1974

TABLE 1.—NDT TEST DATA—ULTRASONIC INSPECTION OF GRAPHITE-EPOXY SPOILERS[a]

Panel		Serial number	Signal attenuation[b]	Satisfactory?	Disposition report number
Planning no.	Part no.				
65-76327-3	TE1	0081		Yes	
	TE2	0082		Yes	
	TE3	0083		Yes	
	TE4	0084	43-60 dB over -11 shim	Yes	S/R 930088
	TE5	0085		Yes	
	TE6	0086		Yes	
	TE7	0087		Yes	
	TE8	0088	43-48 dB transition area (L, center, R); under -11 shim	Yes	S/R 507059
	TE9	0089	43-45 dB transition area (L and R); under -11 shim	Yes	S/R 507055
	TE10	0090	43-48 dB transition area; under -11 shim	Yes	S/R 507058
	TE11	0091	43-54 dB transition area (L and R); under -8 CHF and -11 shim	Yes	S/R 507057
	TE12	0092	43-54 dB transition area (L and R); under -11 shim	Yes	S/R 507056
	TE13	0093	43-54 dB under -11 shim; stripe 7 in. R of CHF	Yes	S/R 640066
	TE14	0094	43-54 dB under -11 shim and -23 doublers	Yes	S/R 640065
	TE15	0095	43-60 dB entire panel between LE and transition area; 43-48 dB over remainder of panel	Yes[c]	S/R 640064
	TE16	0096	43-54 dB stripe 6 in. R of CHF	Yes	S/R 640063
	TE17	0097	43-54 dB upper LE panel area from 5 in. R of -8 CHF to L end rib	Yes	S/R 640062
	TE18	0098	43-54 dB under -11 shim	Yes	S/R 640061
	TE19	0099	43-54 dB transition area (L) and under -23 doublers and -11 shim; stripe 4 in. L of CHF	Yes	S/R 640060
	TE20	0100	43-54 dB entire spoiler area	Yes[c]	S/R 640059
	TE21	0101	43-54 dB entire upper LE panel area	Yes	S/R 640058
	TE22	0102	43-54 dB transition area (L and R), stripes 5 in. L and R of CHF	Yes	S/R 640057
	TE23	0103	43-48 dB over entire spoiler area	Yes[c]	S/R 640056
	TE24	0104	43-54 dB under -11 shim	Yes	S/R 640055
	TE25	0105	No initial NDT performed. Scan after service damage, 1-in.-dia void on upper surface above CHF	Yes[d]	R/T 494681
	TE26	0106	43-54 dB stripe 4 in. of -8 CHF	Yes	S/R 640077
	TE27	0107	43-60 dB under -11 shim; spotty upper panel area	Yes	S/R 640078
	TE28	0108	49-54 dB under -11 shim; upper panel area	Yes	S/R 640079
	TE29	0109	43-54 dB transition area (R); under -23 doublers; -11 shim periphery; stripe 4 in. L of -8 CHF	Yes	S/R 457467
	TE30	0110	43-54 dB transition area (L, center, R); under -11 shim	Yes	S/R 457466
	TE31	0111	43-54 dB all transition area; periphery -11 shim; stripe 5 in. R of -8 CHF	Yes	S/R 457463
	TE32	0112	43-54 dB under -11 shim and stripe 4 in. L of CHF	Yes	S/R 457462
	TE33	0113	43-54 dB under -11 shim and stripe 4 in. L of CHF; 49-54 dB in 1/2-in. dia 8 in. L of CHF and 9 in. forward of TE	Yes	S/R 457461
	TE34	0114	43-48 dB periphery and R side -11 shim; R -23 doubler	Yes	S/R 457460
	TE35	0115	43-54 dB under -11 shim and 4 in. L of CHF	Yes	S/R 457459
	TE36	0116	43-48 dB transition area (L and R); under -11 shim	Yes	S/R 457458
	TE37	0117	43-54 dB transition area (all); under -11 shim	Yes	S/R 457457
65-76327-3	TE38	0118	43-54 dB transition area (L and R); under -11 shim	Yes	S/R 457456

[a] 1-MHz water-column-coupled through-transmission ultrasonic signal; inspection of planning numbers 65-76327-1 and -2 already completed (see sixth quarterly report)

[b] Abbreviations used: L (left), R (right), CHF (center hinge fitting), LE (leading edge), and TE (trailing edge)

[c] Rescan cleared discrepant areas

[d] Repaired-area only

TABLE 2.–737 GRAPHITE SPOILER DISTRIBUTION SCHEDULE AND DATA

Airline	Airplane registry identification	Spoiler location letter[a]	Spoiler serial number	Original spoiler installation			Spoiler installation as of 3-31-74	
				Date	Aircraft hours	Aircraft landings	Aircraft hours	Aircraft landings
PSA	N987PS	A	0003	7-18-73	8 095.3	12 842	9 011	14 369
		B	0006	7-28-73	8 161.4	12 965	↕	↕
		C	0004	7-28-73	8 161.4	12 965	↕	↕
		D	0005	7-18-73	8 095.3	12 842	9 011	14 369
	N988PS	A	0043	7-25-73	4 993.5	8 068	6 201	10 058
		B	0044	7-26-73	5 003.3	8 092	↕	↕
		C	0042	7-26-73	5 003.3	8 092	↕	↕
		D	0045	7-25-73	4 993.5	8 068	6 201	10 058
	N382PS	A	0016	8-2-73	8 651.5	13 711	9 389	14 920
		B	0015	↕	↕	↕	↕	↕
		C	0018	↕	↕	↕	↕	↕
		D	0017	8-2-73	8 651.5	13 711	9 389	14 920
	N984PS	A	0061	8-6-73	8 476.2	13 644	9 357	15 177
		B	0058	↕	↕	↕	↕	↕
		C	0059	↕	↕	↕	↕	↕
		D	0060	8-6-73	8 476.2	13 644	9 357	15 177
	N986PS	A	0110	9-1-73	8 620.9	13 711	9 514	15 103
		B	0111	↕	↕	↕	↕	↕
		C	0109	↕	↕	↕	↕	↕
		D	0108	9-1-73	8 620.9	13 711	9 514	15 103
Lufthansa	D-ABEN	A	0011	8-26-73	11 274	15 681	12 533	17 209
		B	0012	↕	↕	↕	↕	↕
		C	0013	↕	↕	↕	↕	↕
		D	0014	8-26-73	11 274	15 681	12 533	17 209
	D-ABEI	A	0054	9-6-73	11 152	15 328	12 326	16 774
		B	0055	↕	↕	↕	↕	↕
		C	0056	↕	↕	↕	↕	↕
		D	0057	9-6-73	11 152	15 328	12 326	16 774
	D-ABEK	A	0082	9-12-73	11 560	16 962	12 676	18 344
		B	0083	↕	↕	↕	↕	↕
		C	0084	↕	↕	↕	↕	↕
		D	0085	9-12-73	11 560	16 962	12 676	18 344
	D-ABEP	A	0019	10-2-73	11 200	14 884	12 288	16 206
		B	0020	↕	↕	↕	↕	↕
		C	0021	↕	↕	↕	↕	↕
		D	0022	10-2-73	11 200	14 884	12 288	16 206
	D-ABEH	A	0062	10-23-73	11 450	15 759	12 389	16 937
		B	0063	↕	↕	↕	↕	↕
		C	0064	↕	↕	↕	↕	↕
		D	0065	10-23-73	11 450	15 759	12 389	16 937
	D-ABEO	A	0112	11-13-73	11 587	16 011	12 400	17 042
		B	0113	↕	↕	↕	↕	↕
		C	0014	↕	↕	↕	↕	↕
		D	0115	11-13-73	11 587	16 011	12 400	17 042

[a]See figure 6 of fifth quarterly report for spoiler location.

TABLE 2.–CONCLUDED

Airline	Airplane registry identification	Spoiler location letter[a]	Spoiler serial number	Original spoiler installation			Spoiler installation as of 3-31-74	
				Date	Aircraft hours	Aircraft landings	Aircraft hours	Aircraft landings
New Zealand	ZK-NAE	A	0050	7-23-73	10 539	14 075	11 978	16 208
		B	0052	↕	↕	↕	↕	↕
		C	0051	↕	↕	↕	↕	↕
		D	0053	7-23-73	10 539	14 075	11 978	16 208
	ZK-NAC	A	0007	9-15-73	10 861	15 053	12 121	16 709
		B	0008	↕	↕	↕	↕	↕
		C	0009	↕	↕	↕	↕	↕
		D	0010	9-15-73	10 861	15 053	12 121	16 709
	ZK-NAJ	A	0086	9-22-73	5 587	8 565	6 835	10 224
		B	0088	↕	↕	↕	↕	↕
		C	0087	↕	↕	↕	↕	↕
		D	0089	9-22-73	5 587	8 565	6 835	10 224
	ZK-NAD	A	0069	9-29-73	10 787	14 648	11 982	16 197
		B	0066	↕	↕	↕	↕	↕
		C	0068	↕	↕	↕	↕	↕
		D	0067	9-29-73	10 787	14 648	11 982	16 197
Aloha	N73715	A	0049	8-8-73	6 447.5	9 087	7 598	12 058
		B	0046	↕	↕	↕	↕	↕
		C	0048	↕	↕	↕	↕	↕
		D	0047	8-8-73	6 447.5	9 087	7 598	12 058
	N73717	A	0092	8-15-73	5 623.3	7 992	6 644	10 577
		B	0090	↕	↕	↕	↕	↕
		C	0091	↕	↕	↕	↕	↕
		D	0106	8-15-73	5 623.3	7 992	6 644	10 577
	N73711	A	0023	8-18-73	9 206.8	24 932	10 472	28 370
		B	0026	↕	↕	↕	↕	↕
		C	0024	↕	↕	↕	↕	↕
		D	0025	8-18-73	9 206.8	24 932	10 472	28 370
	N73712	A	0107	9-25-73	9 244.3	25 150	10 297	27 954
		B	0078	↕	↕	↕	↕	↕
		C	0104	↕	↕	↕	↕	↕
		D	0098	9-25-73	9 244.3	25 150	10 297	27 954
Piedmont	N735N	A	0071	3-4-74	13 908	22 649	14 107	22 972
		B	0070	↕	↕	↕	↕	↕
		C	0072	↕	↕	↕	↕	↕
		D	0074	3-4-74	13 908	22 649	14 107	22 972
	N738N	A	0030	2-28-74	13 747	22 449	13 949	22 753
		B	0031	↕	↕	↕	↕	↕
		C	0033	↕	↕	↕	↕	↕
		D	0028	2-28-74	13 747	22 449	13 949	22 753
	N740N	A	0095	3-20-74	13 879	22 839	13 953	22 961
		B	0093	↕	↕	↕	↕	↕
		C	0096	↕	↕	↕	↕	↕
		D	0094	3-20-74	13 879	22 839	13 953	22 961
	N749N	A	0116	3-21-74	10 290	15 517	10 346	15 605
		B	0099	↕	↕	↕	↕	↕
		C	0101	↕	↕	↕	↕	↕
		D	0102	3-21-74	10 290	15 517	10 346	15 605

[a]See figure 6 of fifth quarterly report for spoiler location.

TABLE 3.–TASK I FLIGHT SPOILER SERVICE EXPERIENCE (THROUGH 31 MARCH 1974)

Airline	Number of aircraft in evaluation	Number of spoilers in evaluation	Total spoiler hours since installation	Total spoiler landings since installation
PSA	5	20	18 386	30 604
Aloha	4	16	17 956	47 192
National Airways (New Zealand)	4	16	20 568	27 988
Lufthansa	6	24	25 796	31 548
Piedmont	4	16	2 124	3 348
Total	23	92	84 830	140 680

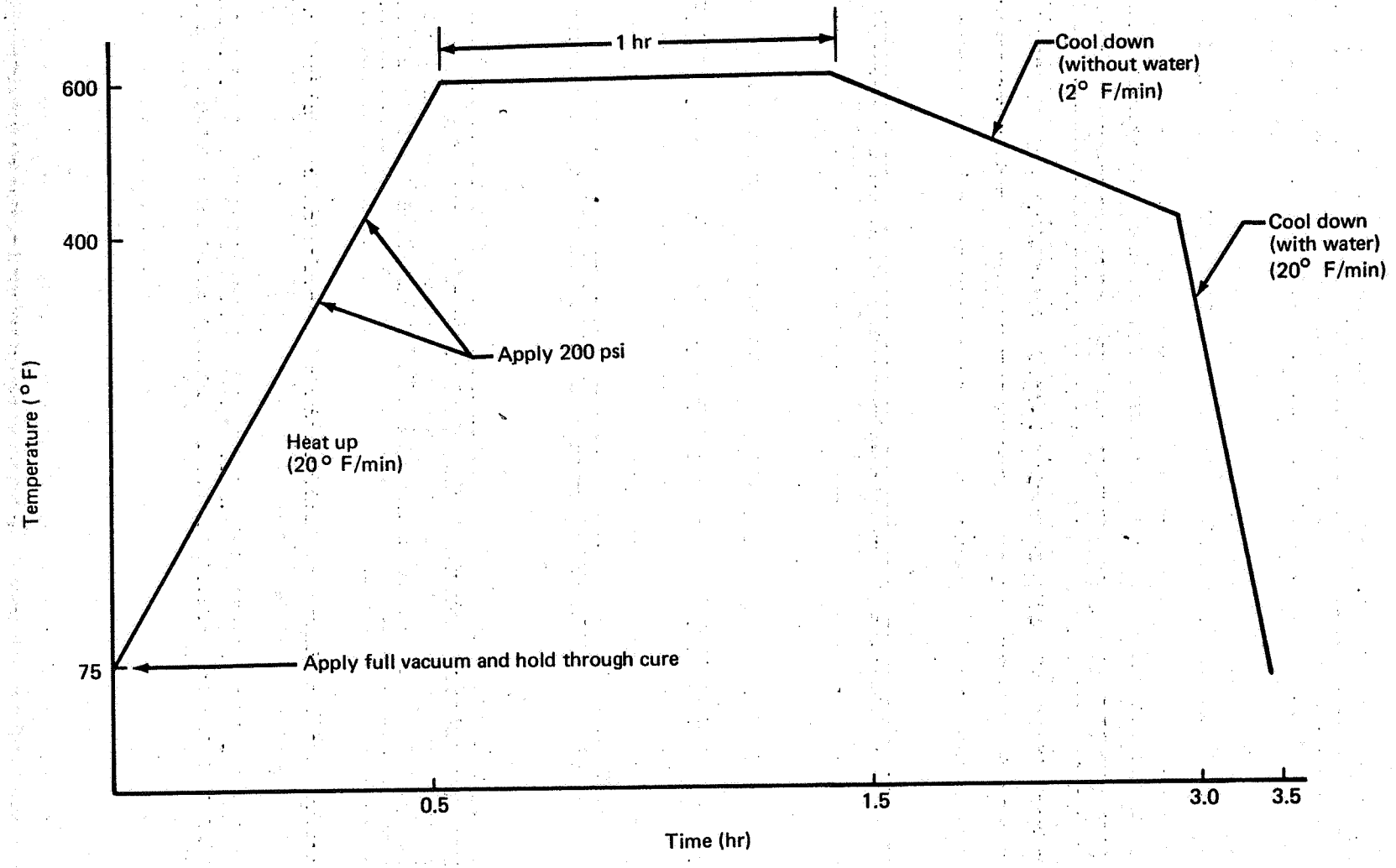

FIGURE 1.—GRAPHITE/POLYSULFONE CURE CYCLE

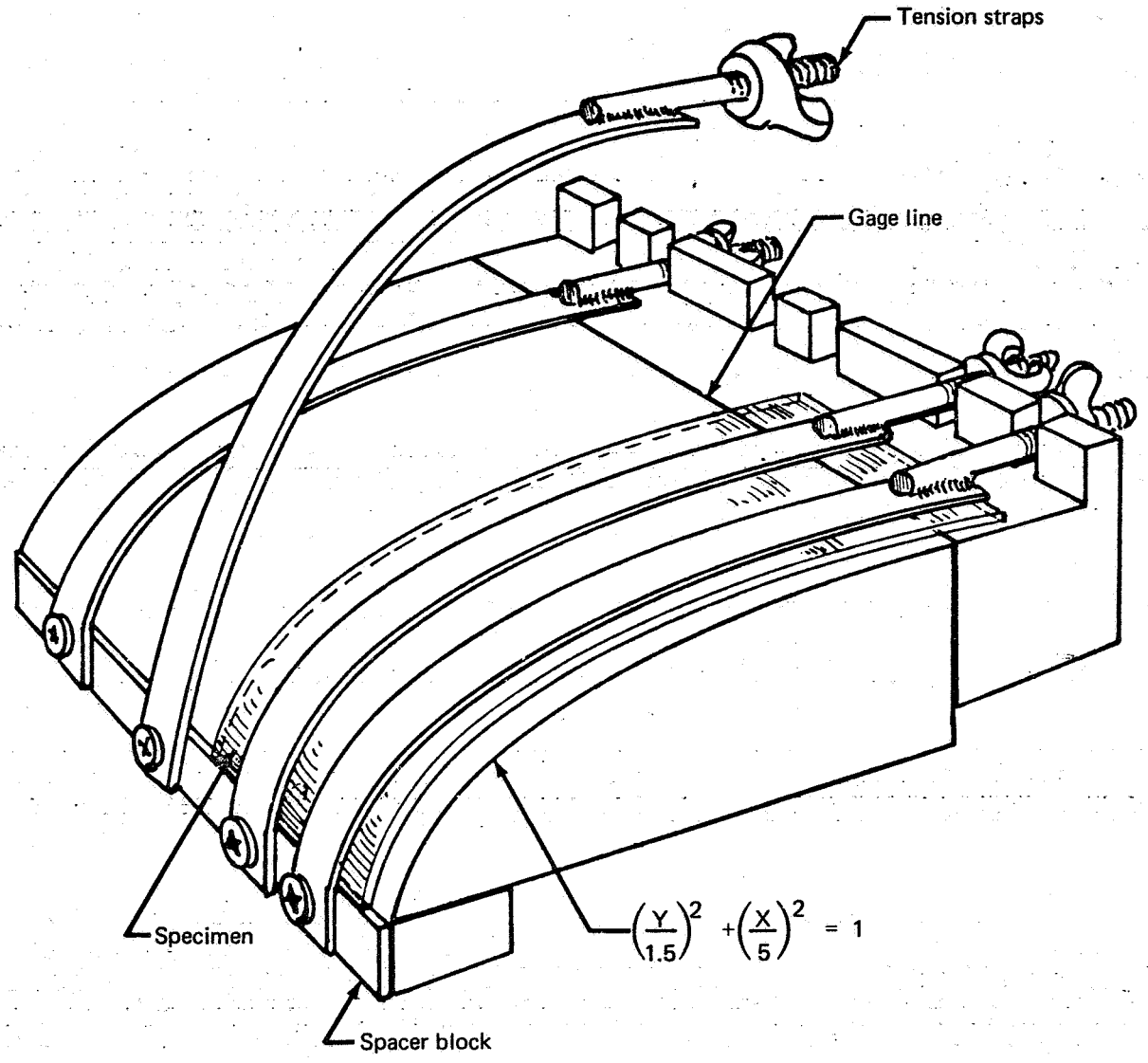

FIGURE 2.—BERGEN STRESS CRACK RESISTANCE TEST JIG

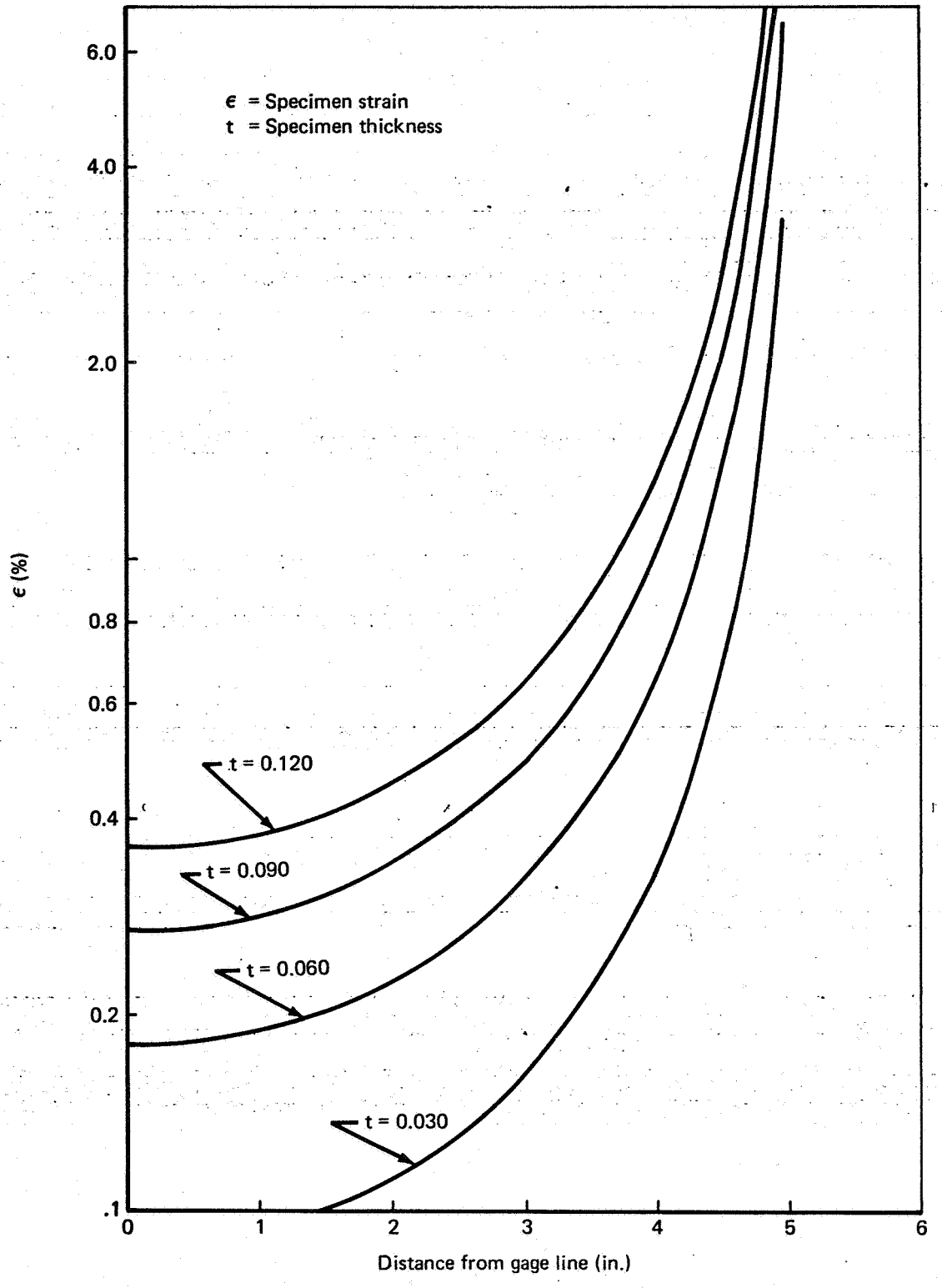

FIGURE 3.—RELATIONSHIP OF INDUCED STRAIN TO CRACK DISTANCE FROM GAGE LINE

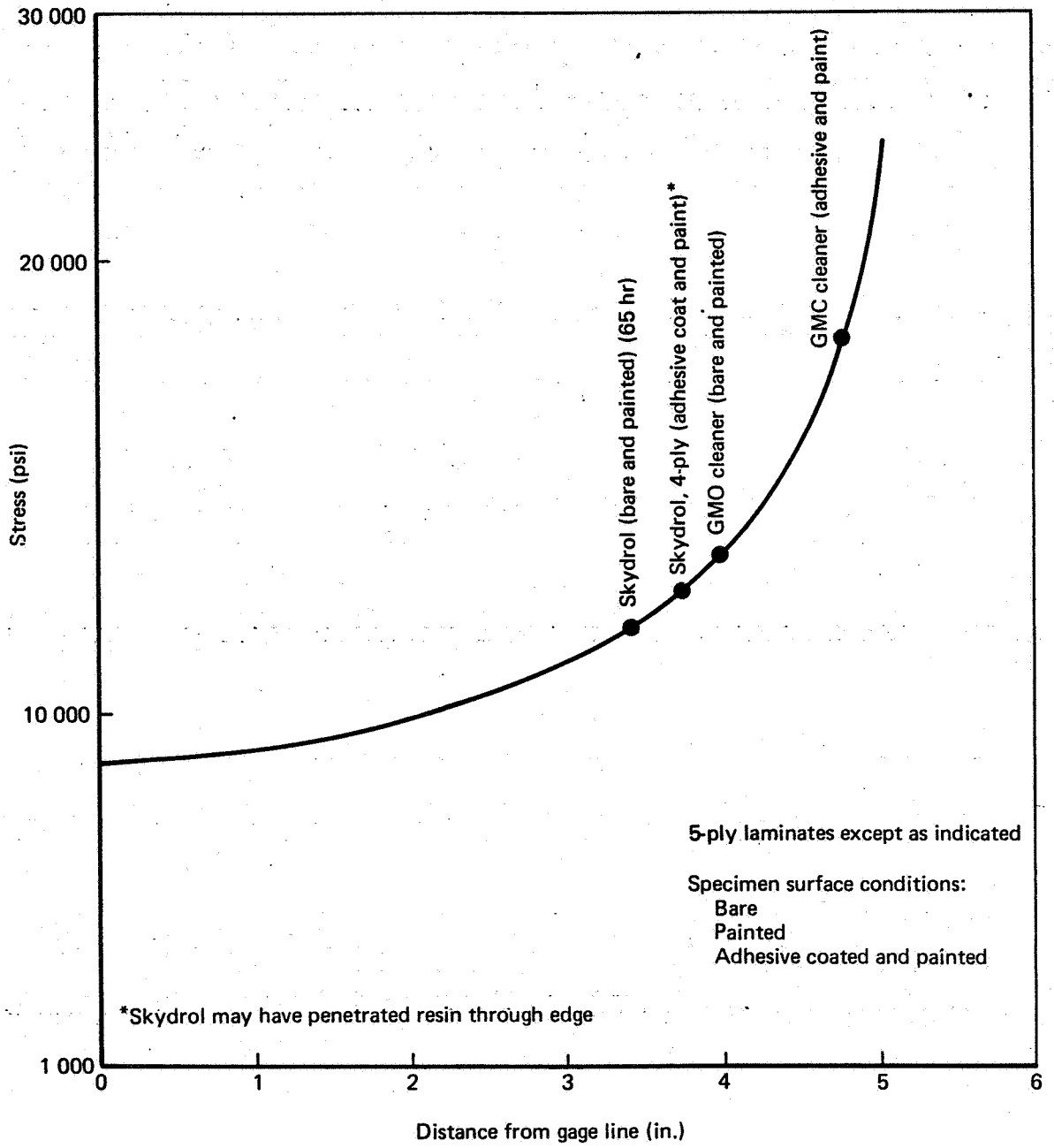

FIGURE 4.—STRESS-CRACK LIMITS IN PRESENCE OF CONTAMINANTS

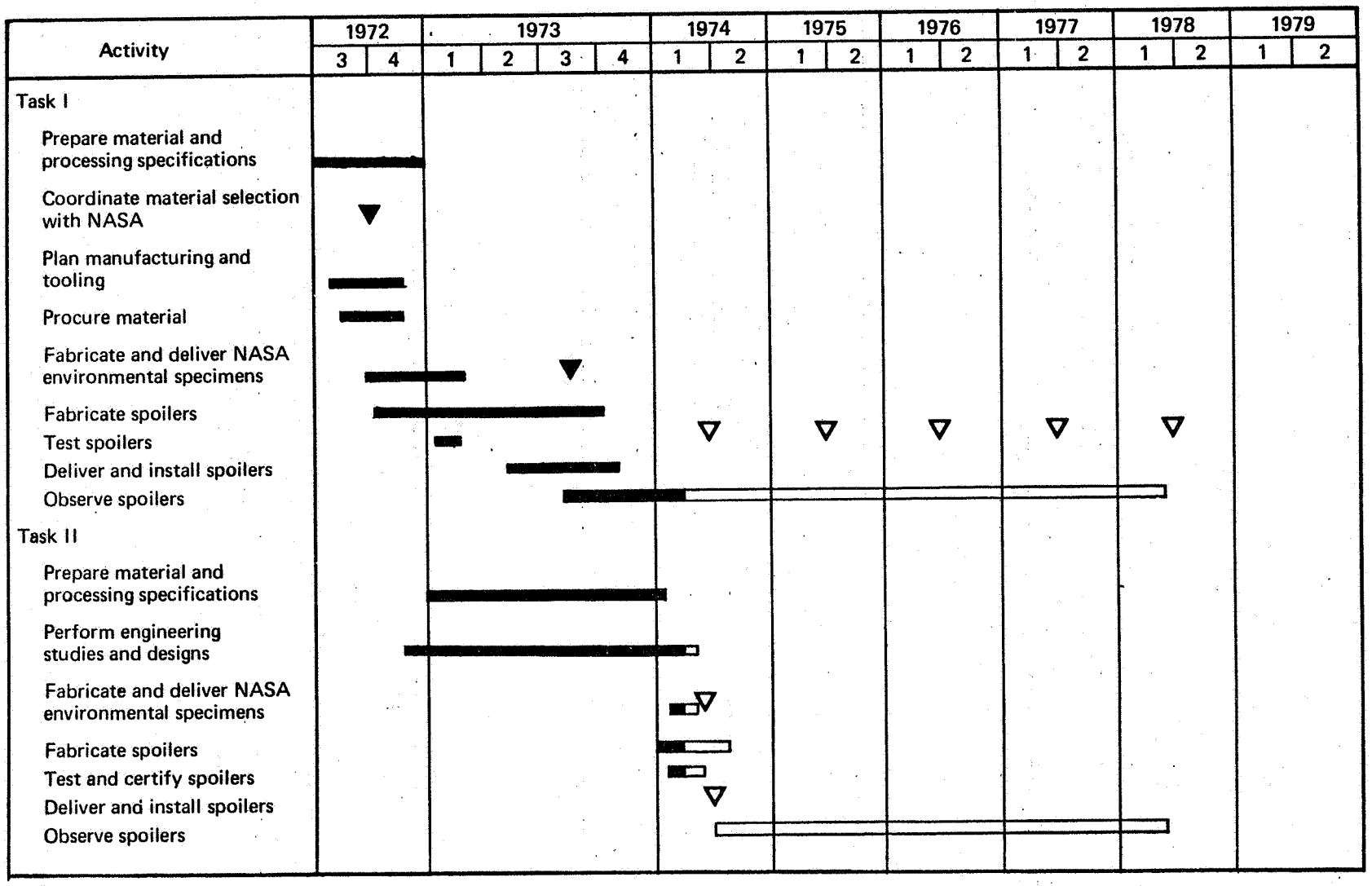

FIGURE 5.—PROGRAM SCHEDULE

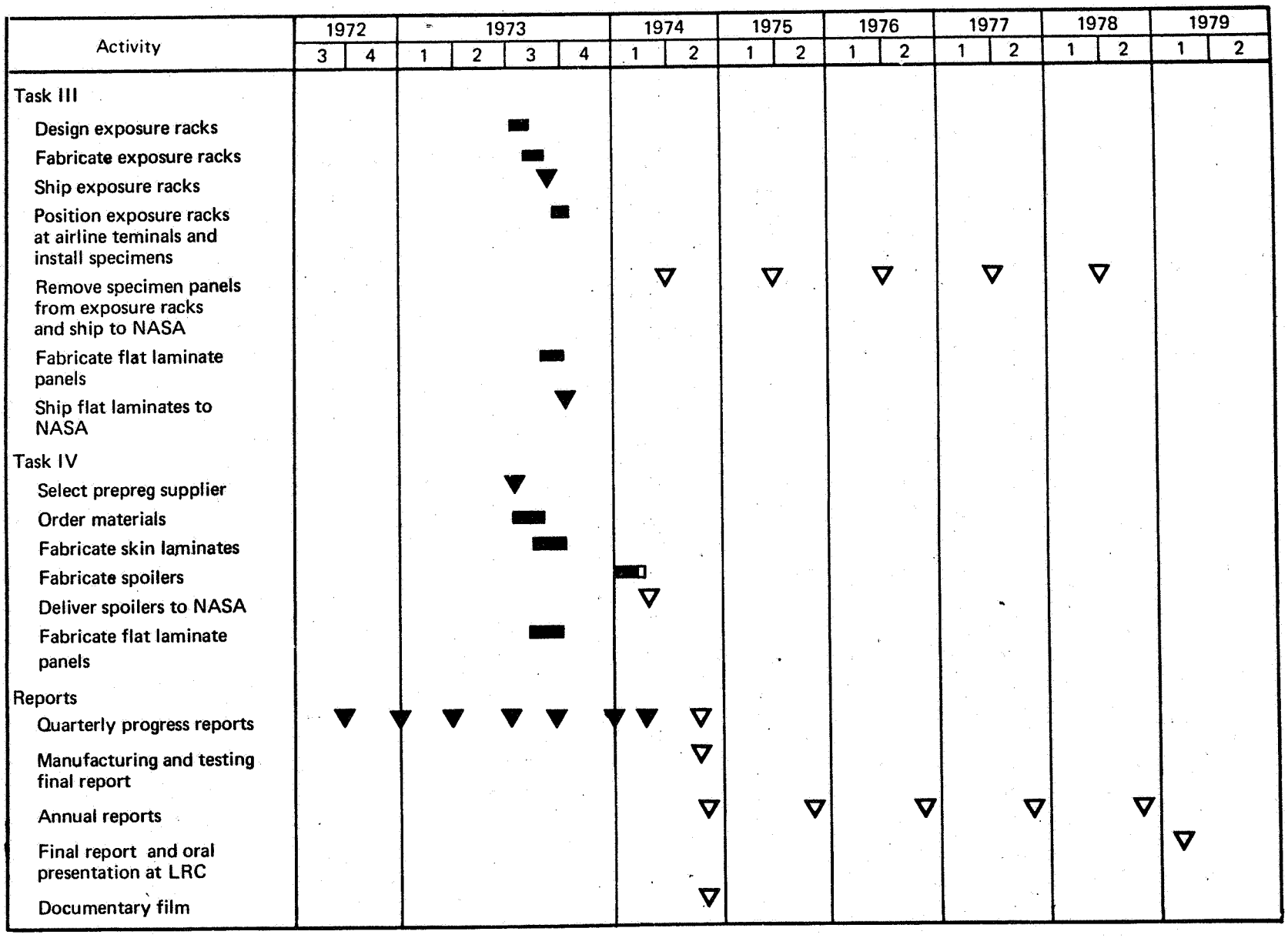

FIGURE 5.—CONCLUDED

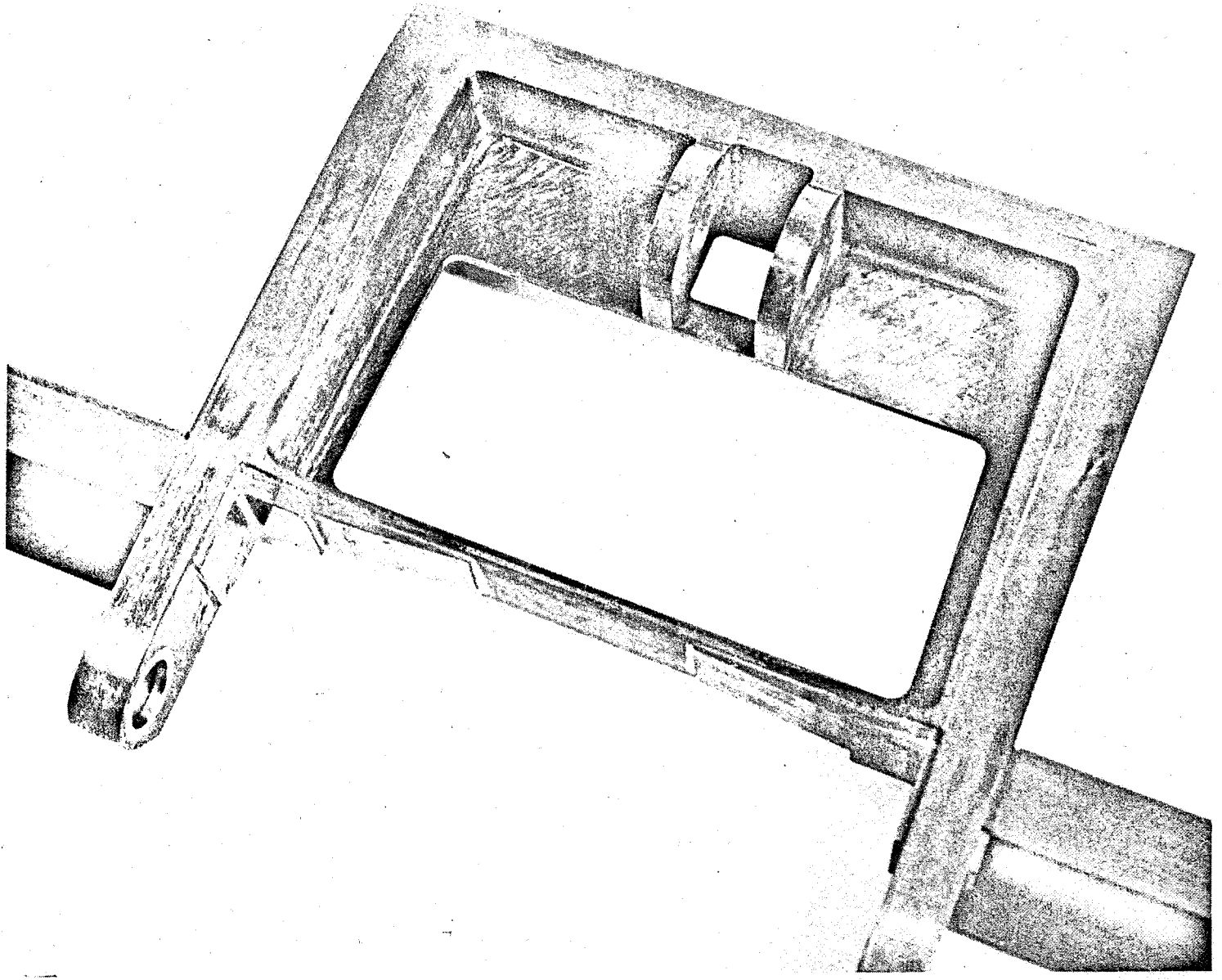

FIGURE 6.—CENTER HINGE FITTING OF INTEGRAL HINGE/SPAR ASSEMBLY FOR 65-76327-XY PROTOTYPE